Post-Soberanes Fire Water Quality Monitoring of the Big Sur and Carmel River Watersheds

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Introduction

The Soberanes Fire located in the Ventana Wilderness along the Big Sur Coast of Central California began on July 22, 2016 as the result of an illegal campfire left unattended in Garrapata State Park. The fire burned through fire-dependent maritime chaparral, consuming 132,127 acres of vegetation for nearly 3 months before complete containment was accomplished on October 13, 2016 (CALFIRE 2016). The fire has since been ranked as the most costly wildfire in United States history, totaling over $208.4 million to control (Thomas 2016).

The Ventana Wilderness is dominated by coastal prairie and chaparral (Greenlee and Langenheim 1990), both of which are dependent on periodic fires to replenish nutrients in the soil. Decades of fire suppression in the area allowed for the accumulation of fuel for the Soberanes Fire, resulting in exceptionally hot flames capable of denuding the land of vegetation and causing significant soil burn (WER 2016). Hydrophobic soils are common after moderate-to-severe soil burns, and result in exaggerated runoff and soil erosion (Smith 2008, Richmond 2008).

The Big Sur River Watershed encompasses a drainage area of 151 square kilometers, with a hydraulic length of 27 kilometers, while the Carmel River Watershed encompasses a drainage area of 660 square kilometers with a hydraulic length of 58 kilometers (Smith et al. 2008). Both watersheds are geologically characterized by steep hill slopes and deeply weathered, pervasively fractured bedrock, resulting in high erosion potentials (Christensen and Geisler 2009, Richmond 2008, Smith et al. 2008). In addition to increased sediment flow and associated turbidity, wildfires have been shown to increase concentrations of water quality parameters such as phosphate and nitrate. Increases in turbidity and nutrient levels may result in alterations to the ecological structure of the watersheds, including shifts toward increased algal biomass and decreases in macroinvertebrate assemblages (Earl and Blinn 2003). pH of rivers and streams may also be affected by transported ash and soil from burned areas, causing increases in pH of as much as two to three units (Ranalli 2004). All changes in water quality parameters may place stress on both fish and macroinvertebrate populations.

Expected Changes in Water Quality

As a result of the Soberanes Fire, measurable water quality parameters such as turbidity, temperature, pH, conductivity, dissolved oxygen (DO), and phosphate and nitrate concentrations will vary from pre-fire and historically observed values, corresponding with increased water discharge after precipitation events over the course of the next two years. We hypothesize the duration of high turbidity levels will increase thus water temperature will be higher than pre-fire conditions. We also expect to observe a rise in pH after a precipitation event. Likewise, we predict phosphate and nitrate concentrations will be higher after precipitation events and a general decrease in DO will be observed between precipitation events, after turbulence associated with high water flows and hydrologically increased oxygenation has ceased.

Table 1. Average, standard deviation, minnimum, maximum, and range of water quality parameters in the Big Sur River at PBS State Park

Parameter	Average	Standard Deviation	Minimum	Maximum	Range
Water Temp (^{o}C)	12.17	1.58	9.00	15.00	6.00
Air Temp (^{o}C)	17.04	4.96	10.20	33.00	22.80
Discharge (cfs)	395.48	463.82	14.00	1560.00	1546.00
DO (ppm)	14.23	3.12	10.50	20.00	9.50
pH	7.78	0.21	7.40	8.20	0.80
Turbidity (FAU)	95.38	252.90	0.00	1000.00	1000.00
Phosphate (mg/L)	0.65	0.72	0.18	2.63	2.45
Nitrate (mg/L)	0.23	0.74	0.00	3.00	3.00
Salinity (ppt)	0.41	0.76	0.00	2.00	2.00
Conductivity (ppm)	185.96	40.88	92.10	236.00	143.90

Table 2. Average, standard deviation, minnimum, maximum, and range of water quality parameters in the Carmel River at Garland Ranch

Parameter	Average	Standard Deviation	Minimum	Maximum	Range
Water Temp (oC)	11.96	2.96	5.00	18.00	13.00
Air Temp (oC)	15.09	4.94	5.20	24.00	18.80
Discharge (cfs)	431.46	584.09	5.30	1650.00	1644.70
DO (ppm)	13.22	3.32	9.30	20.00	10.70
pH	7.51	0.29	6.42	8.10	1.68
Turbidity (FAU)	47.82	122.78	0.00	578.00	578.00
Phosphate (mg/L)	0.72	0.67	0.11	2.32	2.21
Nitrate (mg/L)	0.14	0.53	0.00	2.50	2.50
Salinity (ppt)	0.26	0.54	0.00	2.00	2.00
Conductivity (ppm)	152.10	48.18	80.80	211.80	131.00

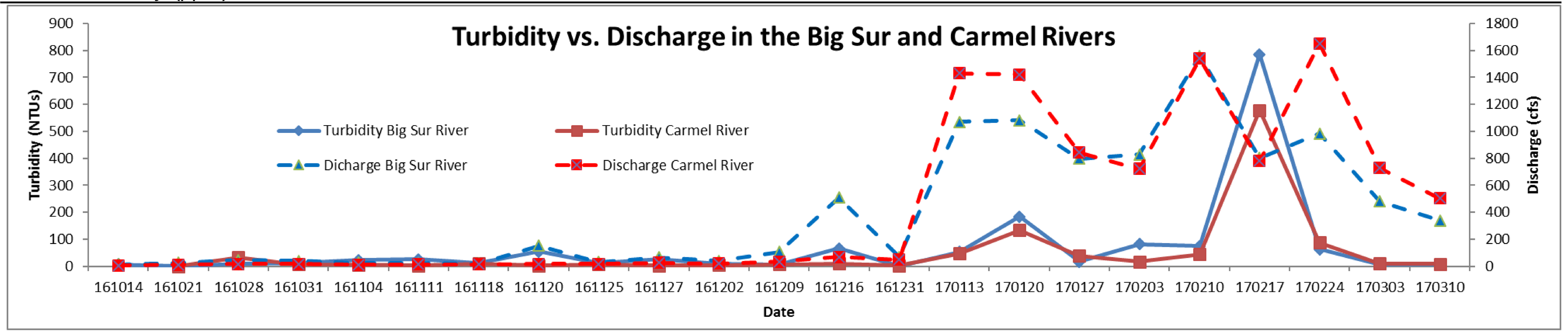

Figure 1. Relationship between changes in turbidity and discharge over time of the Big Sur River at Pfeiffer Big Sur State Park and the Carmel River at Garland Ranch State Park

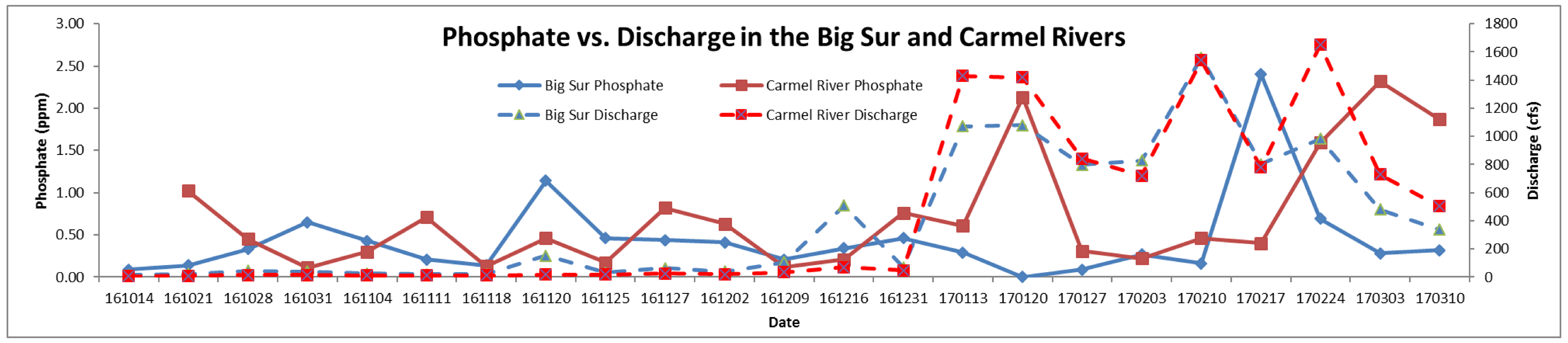

Figure 2. Relationship between changes in phosphate and discharge over time of the Big Sur River at Pfeiffer Big Sur State Park and the Carmel River at Garland Ranch State Park

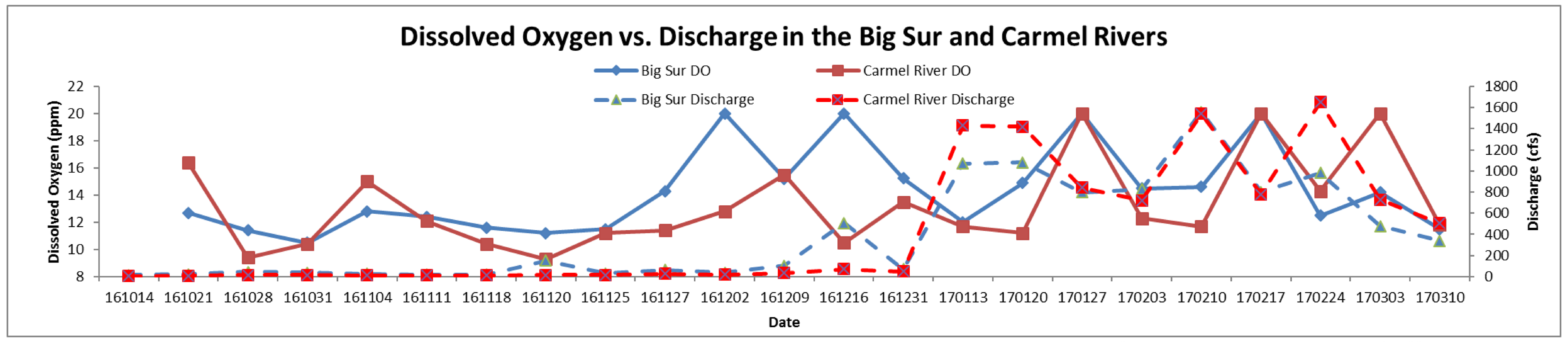

Figure 3. Relationship between changes in dissolved oxygen and discharge over time of the Big Sur River at Pfeiffer Big Sur State Park and the Carmel River at Garland Ranch State Park

Discussion

Water quality was tested each week from October through March at a total of eleven locations on six rivers and streams in Monterey County, including three locations along the Carmel River and three locations along the Big Sur River. The two rivers are close in size and length, and have had similar discharge during the rains this winter (Fig. 1). Because the Carmel River Watershed was only slightly impacted by the Soberanes Fire while the Big Sur Watershed was highly impacted, water quality of the Carmel River is being used as a control during the duration of this study.

Assessing such parameters as phosphate, nitrate and dissolved oxygen (DO) concentrations, as well as turbidity provides information on ecological health of aquatic systems. Post-fire soils result in increased sediment runoff (Smith 2008, Richmond 2008) which can lead to higher turbidity levels in aquatic systems. The lag time between high discharge and corresponding high turbidity levels (Fig. 1) is likely a result of the time needed for precipitation to mobilize sediment to water. Increases in turbidity can not only directly affect aquatic predators by reducing visibility, clogging gills, and suffocating eggs, but may also reduce the depth of the photosynthetic zone in an aquatic ecosystem, creating a large aphotic zone which decreases primary productivity (Bruton 1985).

Phosphate appears to increase as discharge increases (Fig. 2). This is likely a correlation to increases in turbidity, as phosphate is transported by clinging to sediments (Grayson etal. 1996). Excess nitrate and phosphate can increase aquatic plant growth and lead to anthropogenic eutrophication of the water body, reducing DO (Jensen and Anderson 1992). Nitrate data is not graphically shown due to lack of space and the tendency for phosphate be the limiting factor necessary to drastically increase plant growth with the potential to create eutrophic conditions (Dillon and Rigler 1974). DO appears to increase when discharge increases (Fig. 3). This is likely caused by increased aeration of fast-moving turbulent water.

Water quality parameter data will continue to be collected through October 2017 for all eleven locations to provide a full year of water quality data to be used by CSUMB classes including but not limited to Environmental Science, Environmental Biology, Aquatic Ecology, and Statistics courses. Data collected and analyzed during the course will also be presented to and be made available to the Carmel River Conservancy and California State Parks.

Figure 4. Samples collected after heavy precipitation. Carmel River at Garland Ranch State Park is shown in vial 1 and Big Sur at Pfeiffer Big Sur State Park is shown in vial 10. Vials 5-6 show high turbidity levels at Soberanes Creek, Garapatta Creek, and Mill Creek all of which are sites closest to the location of the fire.

Acknowledgements

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